6 CONCLUSIONS AND LIMITATIONS

The GIS nonpoint source pollution assessment method discussed in the preceding chapters has been shown to present a viable technique of characterizing the nonpoint source contributions to pollution within a watershed or geographic region. Advantages of the method are outlined below:

- By virtue of the fact that values for predicted and observed concentrations are comparable, the GIS nonpoint source assessment method is seen to provide relatively accurate estimates of pollutant loads and concentrations throughout the stream network of a hydrologic unit. Particularly along smaller streams, where few or no point sources exist (e.g. Copano Creek), concentrations predicted via the assessment method match quite well with average observed concentration values.
- The method also provides an efficient way to identify specific locations or regions where elevated levels of pollutant concentrations may be expected. In particular, this study has shown that the Aransas River watershed, with a large percentage of its area occupied by agricultural lands, includes locations where elevated nutrient levels are expected. More sampling is warranted in this subbasin, particularly downstream from Beeville, where the partitioning between nonpoint and point source nutrient loading is still unclear.
- Use of the GIS nonpoint source pollution assessment method also has some logistical advantages that allow for adaptation to other study areas. This method makes use of all recorded streamflow and pollutant concentration data available in the basin and synthesizes the data in a consistent and logical way across the basin. Most of the data sources used for this study are publicly available in a digital format and the data pertinent to the study area are easily extractable from each database.
- Also, the procedures used for this method employ standard Arc/Info and ArcView GIS commands and routines and the necessity for external programming scripts is limited to data reformatting routines.
- By including estimated point source loads as per the simulation method described in sections 4.6 and 5.2, predicted concentration levels in larger streams, where point sources are known to exist, are more closely correlated with average observed concentrations. The practice of accounting for the full difference between

predicted and observed pollutant concentrations with a single point load, however, is not expected to represent actual conditions in a watershed the size of the San Antonio-Nueces coastal basin. Optimally, point loads should be accounted for with values of reported annual loads or permitted average concentrations for all of the permitted point source effluents within the basin.

- The use of the optimization routine, intended for explicit determination of land use-based expected mean concentration values, became a method of adjusting the literature-based expected mean concentrations, due to the lack of sufficient Surface Water Quality Monitoring stations with significant numbers of pollutant measurements in the basin. For future nonpoint source pollution assessments, an equal number of concentration balance equations and land use expected mean concentration variables are recommended, along with a fully documented set of point source loads.

While the advantages of the GIS nonpoint source pollution assessment method described in this report are plainly evident, there are also a number of limitations with this application of the method that should be addressed for future assessments:

- Since the assessment is performed for average annual conditions, results are given for mean annual flow and average annual cumulative load. These steady state results do not consider variations within years or from year to year. Figure 4.9 shows that recorded streamflows are highly correlated in space throughout the basin. One way to model temporal variations in flow would be to use the Mission River gauge as an index defining temporal flow variations throughout the basin and use the method illustrated through equation 4-2 to infer temporal flows at other locations in the basin. This would provide approximate flow profiles for other locations and would facilitate the performance of event-based nonpoint source analyses.
- The literature-based expected mean concentrations assume constant values associated with each land use and are not considered to vary from event to event or between different land use subcategories. This assumption might be relaxed by considering constituent event mean concentrations (Huber, 1993) instead of expected mean concentrations. By considering a series of runoff events and the measured pollutant event mean concentrations associated with each event, a distribution of event mean concentrations can be established and a representative concentration can

be determined and applied to all cells upstream of the particular measurement location. These values could then be used in an event-based nonpoint source pollution assessment.

- Transport of pollutants is considered to be conservative throughout this study, i.e. no loss or decay of pollutants is considered. In the future, this limitation may be addressed through use of a water quality simulation model, such as the EUTRO5 module of WASP5, which includes a kinetics option for the modeling of nutrient concentrations.
- For comparison purposes, representative observed pollutant concentrations are established by averaging all observed pollutant concentrations at a particular sampling location. This averaging is done without consideration of flow conditions at the time each measurement. A more detailed study might classify the observed concentrations according to whether the corresponding streamflow is high, intermediate, or low. In this way, more appropriate values for average observed pollutant concentration can be established for an event-based assessment. Additionally, consideration and exclusion of outlying data points might be included as a method to refine the observed pollutant concentration values.
- The rainfall/runoff relationship established in section 4.2 is determined from the streamflow data of just five gauges. The runoff grid shown in Figure 4.12 represents an extrapolation across the basin of the best linear fit for the five data points. As a result, the rainfall/runoff relationship, while applied to the whole basin, is only valid for the precipitation range between 783 and 924 mm/yr. Actual precipitation in the San Antonio-Nueces coastal basin ranges from 739 to 985 mm/yr. By including additional USGS streamflow gauges in watersheds immediately adjacent to the San Antonio-Nueces basin, a rainfall/runoff relationship can be established for a wider range of precipitation values. By ensuring that two of the additional gauges drain areas receiving less than 739 mm/yr and more than 985 mm/yr of rain, respectively, a rainfall/runoff relationship that is valid for the complete basin can be established. This would also resolve the issue of having to redefine the runoff for cells receiving less than 759 mm of rain per year with values of zero.

The GIS nonpoint source pollution assessment method is a useable, reliable, and repeatable means of establishing nonpoint source pollution estimates in a watershed or geographic region. Consideration of the above limitations for future applications of the method will provide for a more comprehensive analysis. In time, an equivalent vector-based procedure may be developed completely within the Avenue object-oriented programming environment of ArcView so that a stand-alone model may allow for even wider use of the method.